Free-Space Optical Data Bus for Spacecraft

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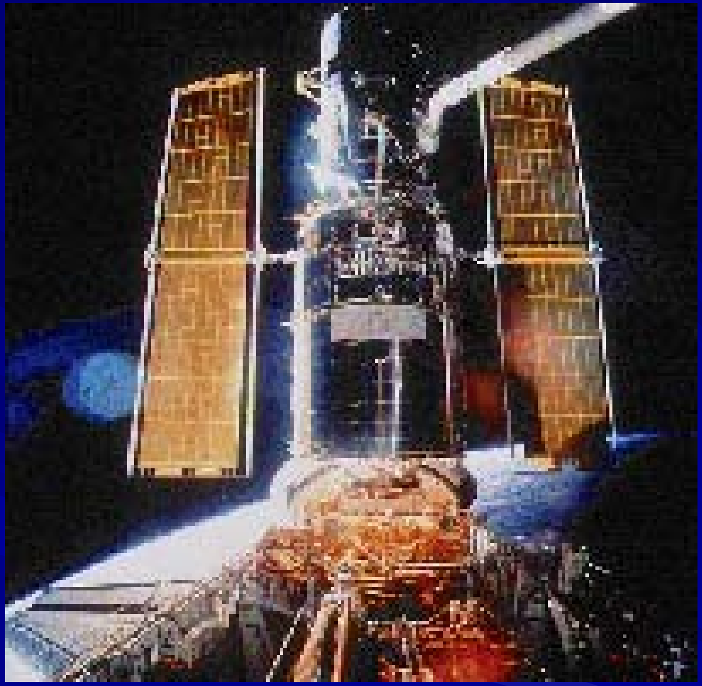
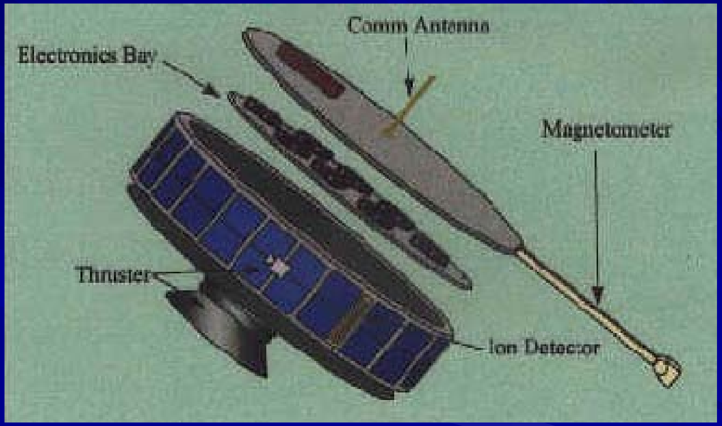
Background

- Many fiber optic data busses have been flown
  - E.g. SAMPEX, MPTB, MAP, XTE, HST and PSE
  - Numerous benefits
    - Potentially increased bandwidth
    - Ease of integration
    - Fewer EMI/EMC issues
    - Reduced weight



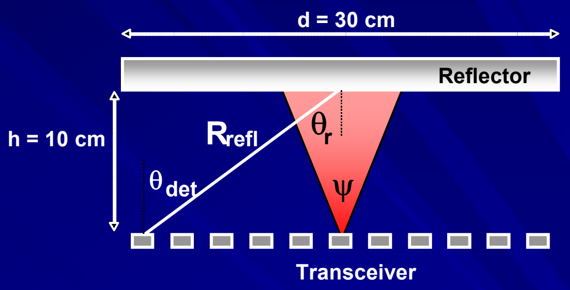
Free-Space Optical Bus

- JHU/APL investigated free-space data bus
- Advantages
  - No cable and connector issues
    - outgassing effects, thermal and radiation degradation of fiber optic cable
    - Fewer parts
    - Less weight
    - Simpler packaging?
    - Easier integration, testing & troubleshooting
- Disadvantages
  - Packaging constraints
    - Common chamber
    - Limited distance ($1/R^2$)
    - Greater sensitivity of diodes?
- Potential application in nano-spacecraft



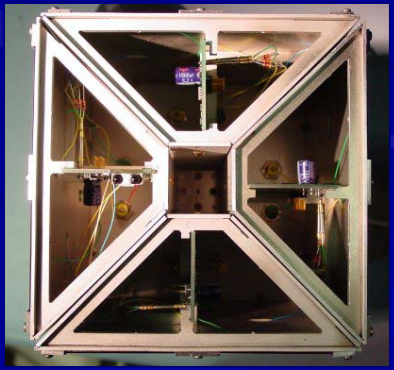
3 Project Elements

- Model of potential layout
  - bidirectional reflectance distribution function (BRDF) testing



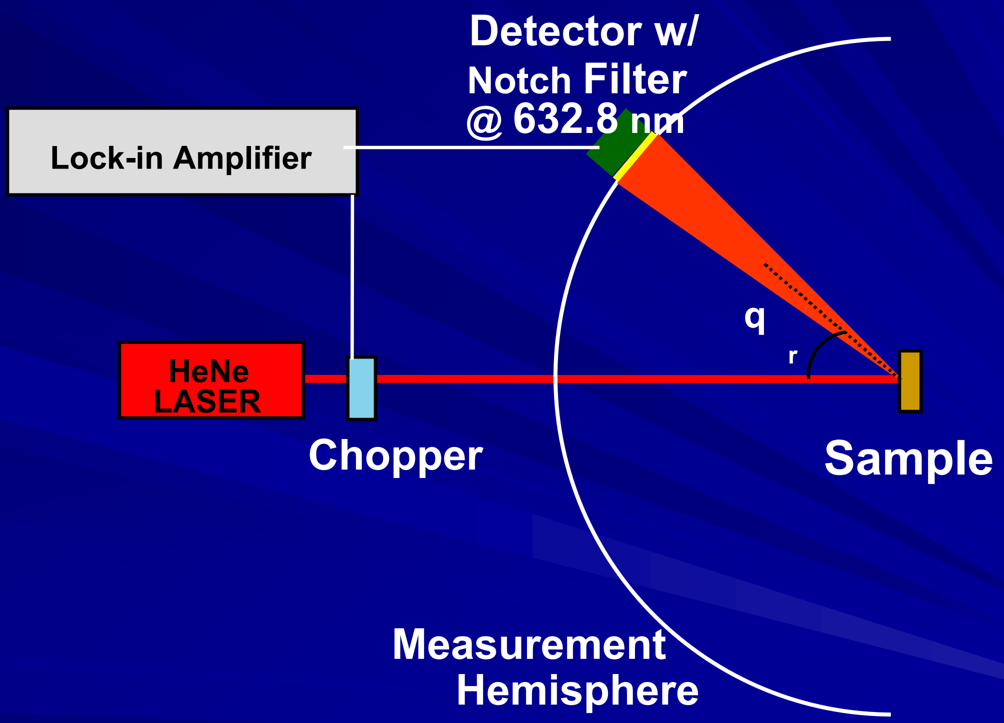
- Bench-top testing of modified Mil-STD-1553 data bus

- Test model demonstrating a 115.2KB UART (RS-232) “multi-drop” type of network.

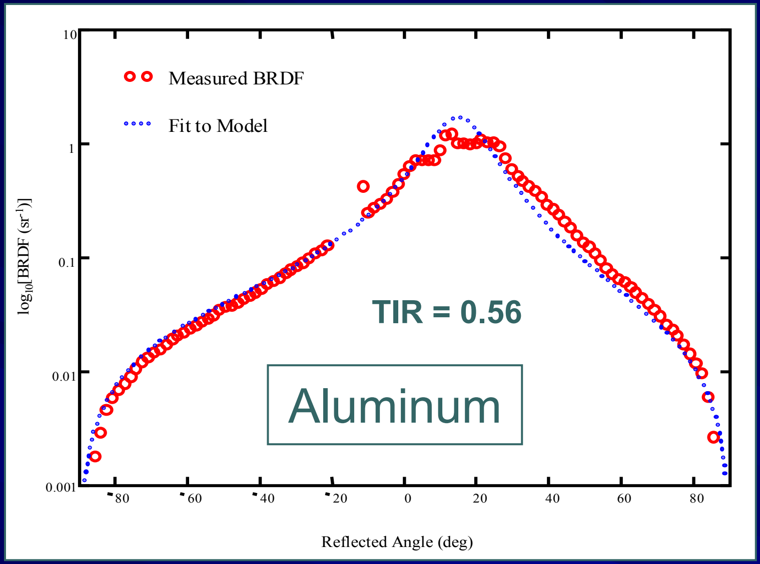


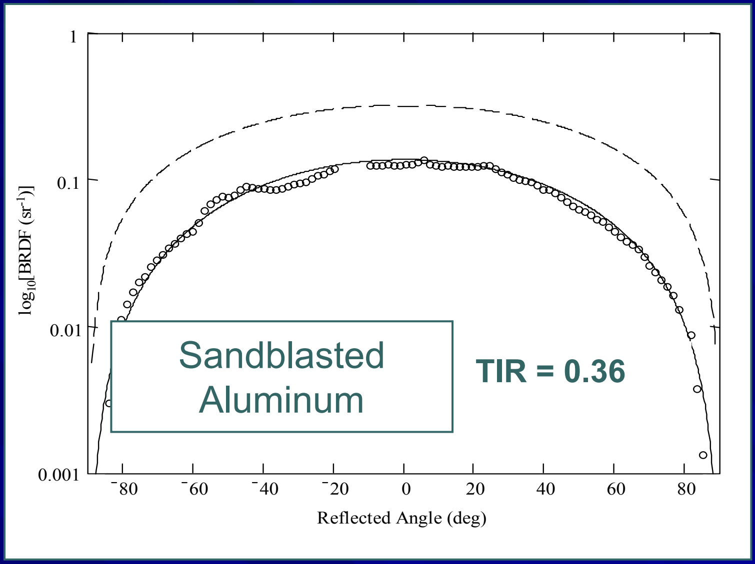
BRDF Measurements

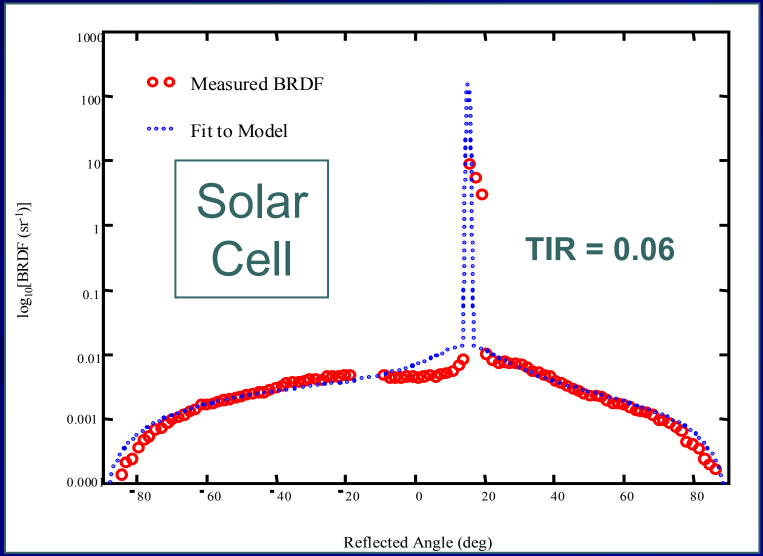
- BRDF behavior of material critical
- Energy reflected varies with angle

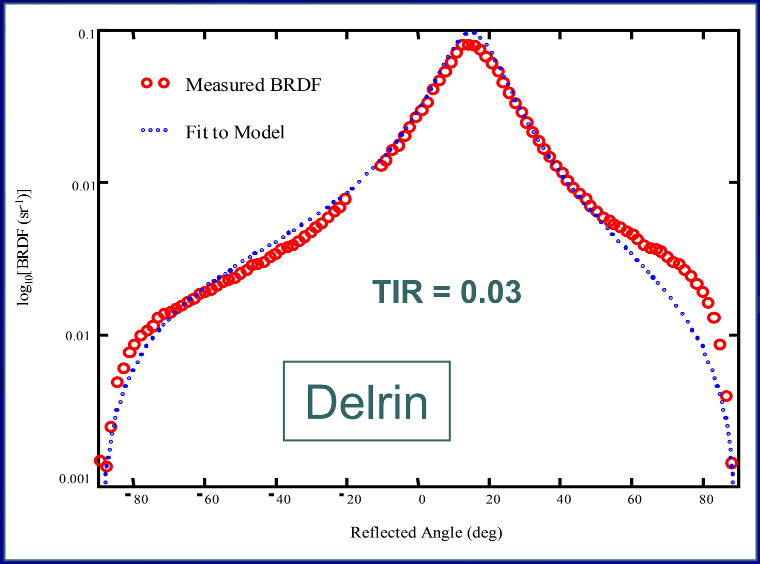


BRDF Data


Measured BRDF
Fit to Model
TIR = 0.56
Aluminum
log10[BRDF (sr-1)]
Reflected Angle (deg)

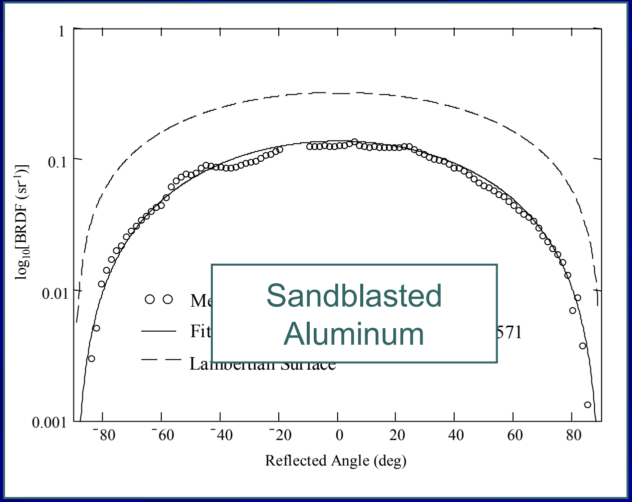

Sandblasted Aluminum
TIR = 0.36
log10[BRDF (sr-1)]
Reflected Angle (deg)


Measured BRDF
Fit to Model
Solar Cell
TIR = 0.06
log10[BRDF (sr-1)]
Reflected Angle (deg)


Measured BRDF
Fit to Model
TIR = 0.03
Delrin
log10[BRDF (sr-1)]
Reflected Angle (deg)

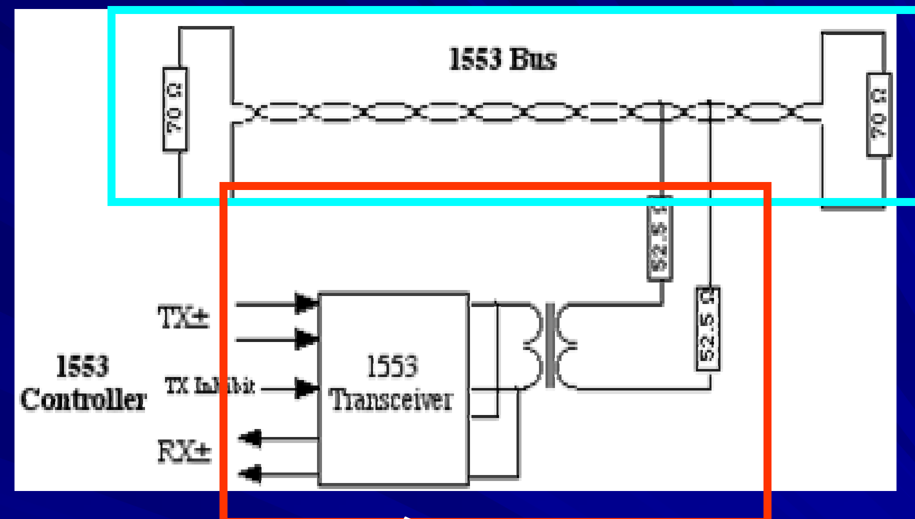
Model Results

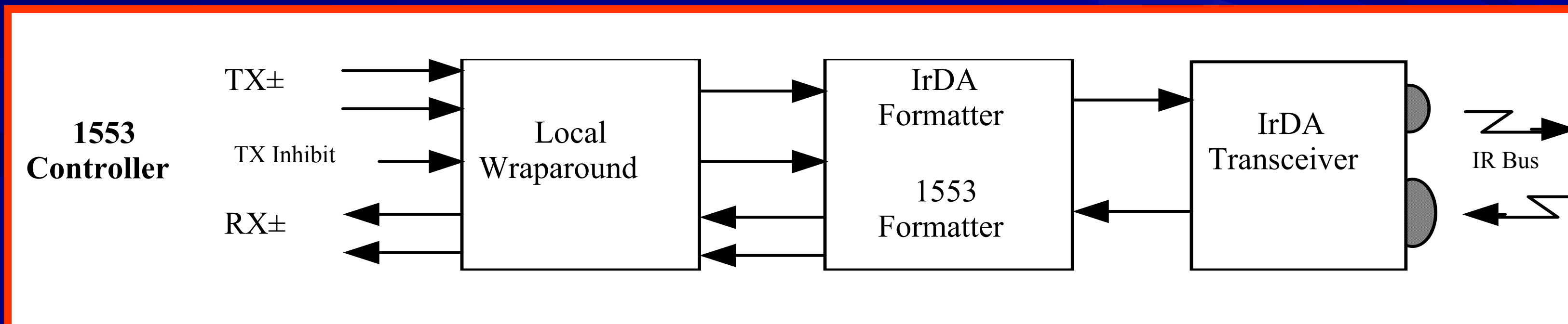
- For largest angle range, surfaces should be Lambertian scattering
  - Sandblasted aluminum
- Reducing the distance between transceivers and reflective material has mixed effects
  - Change in path length vs. change in angle
- Diode lens angle important
- Overall - System design is a geometry/transceiver compromise



Bench-Top Testing

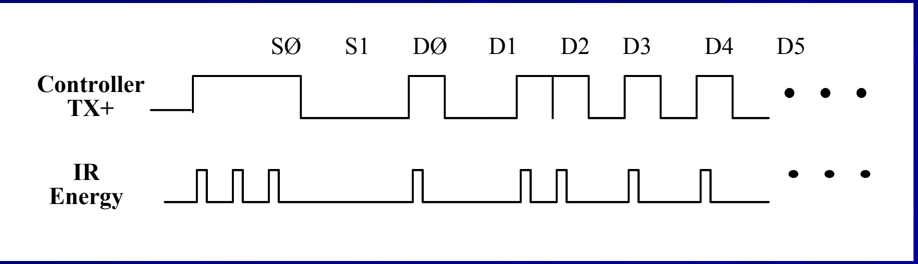
- 1553 bus reformatted to IrDA transceiver
- Local wraparound and formatting from 1553 to IrDA and vice versa are implemented in a Xilinx 9536

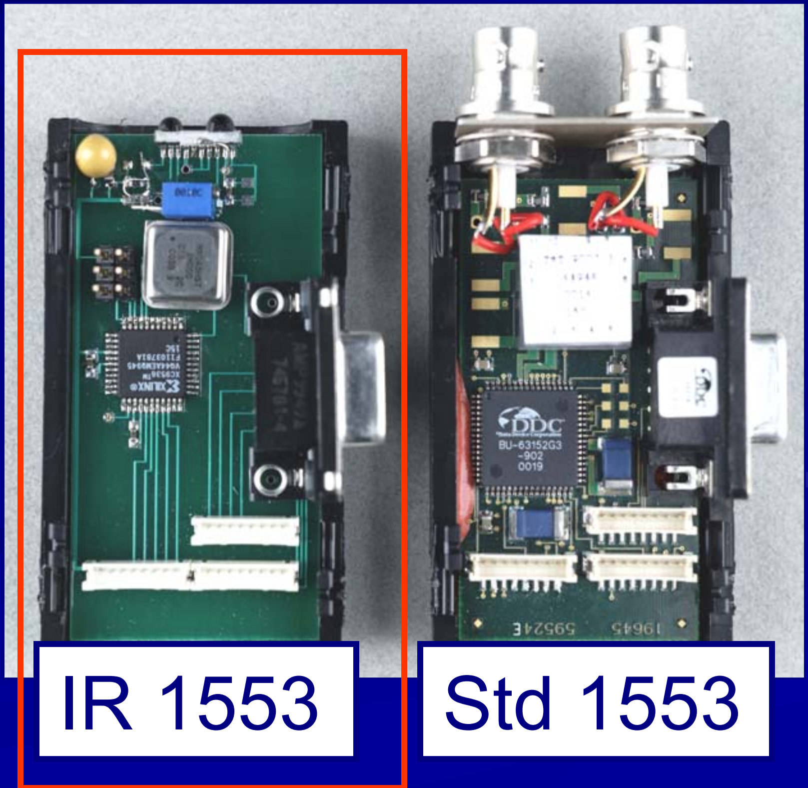




Bench-Top Testing

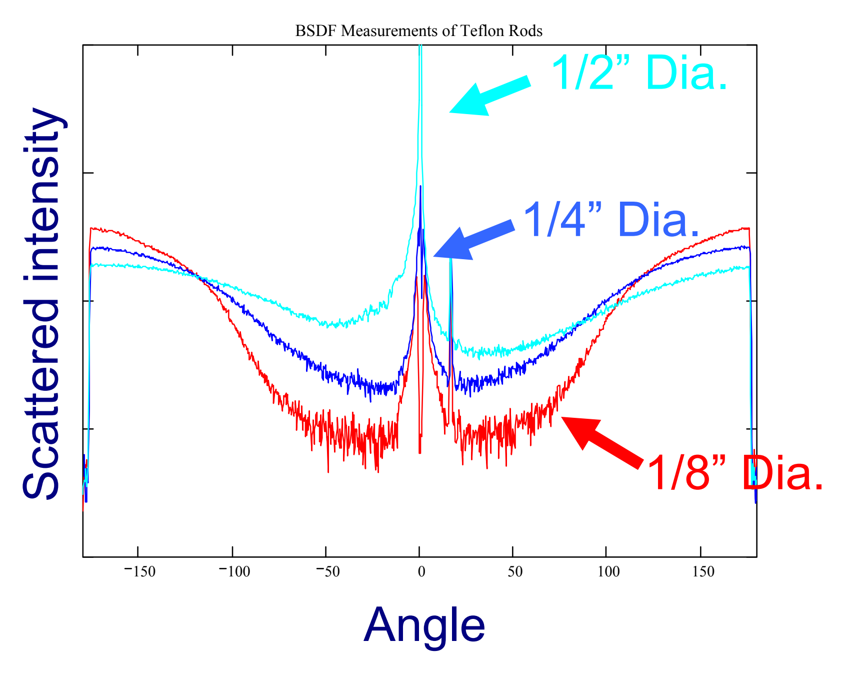
- 125ns IR pulse equaled 500ns 1553 pulse
- *MIL-STD 1553 BC/RT/MT PCMCIA Tester/Simulator Card* from Data Device Corp. was model for form, fit and function.
- IrDA transceiver is the HSDL-3600 from Agilent
- System implemented had
  - No radiation tolerance
  - No redundancy





Diffuser Rod

- Diffuser rod – behaves like fiber optic cable
  - No connectors
  - More reliable, rugged durable, easier to install
  - Lower performance than fiber optic cable
- Test data shows approach has potential



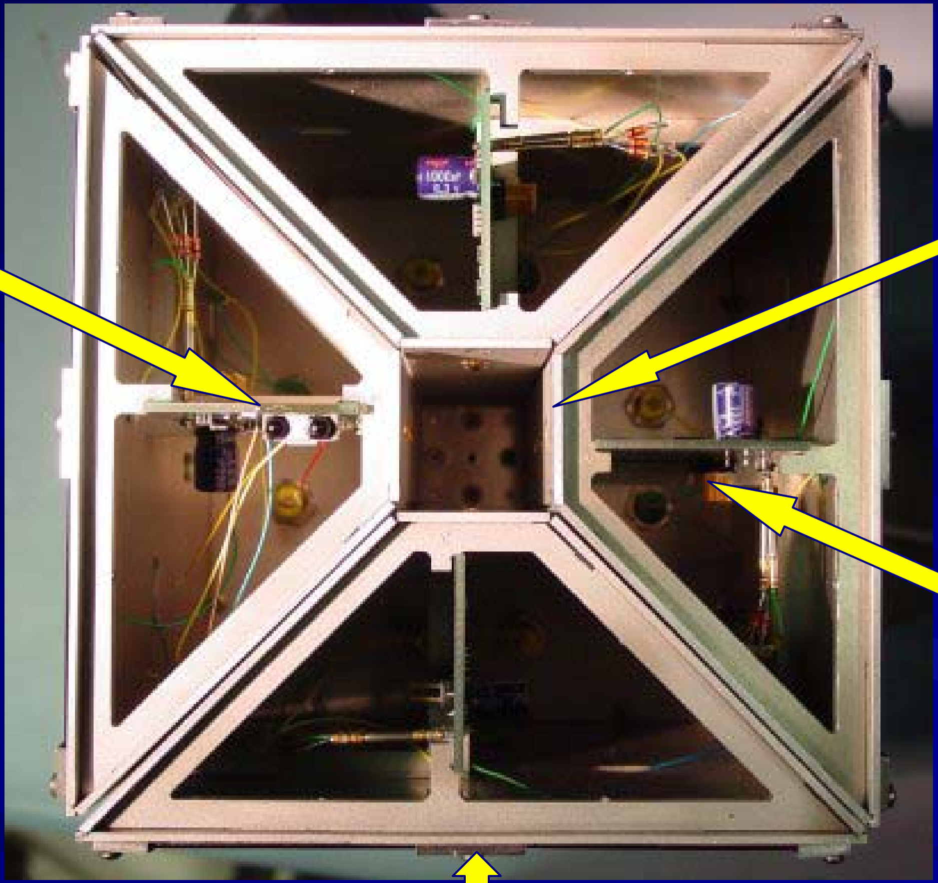
Test Model

- Test model built using 2 IR comm. systems
  - Internal IR comm. – 115.2 K Baud UART (RS-232) controller
    - multi-drop network inside cavity
  - External comm. - IrDA
- Each quadrant solar cell powered
- When solar cell is illuminated, signal is generated that is transmitted to PC base station

View from above

IrDA transceiver

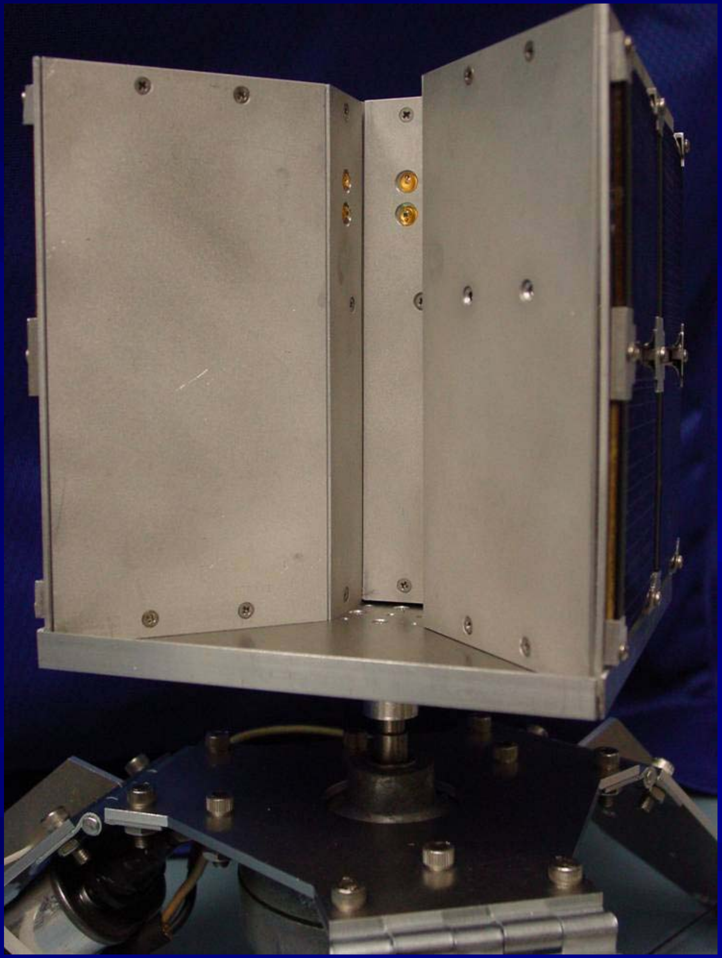
Internal cavity with RS232 transceivers

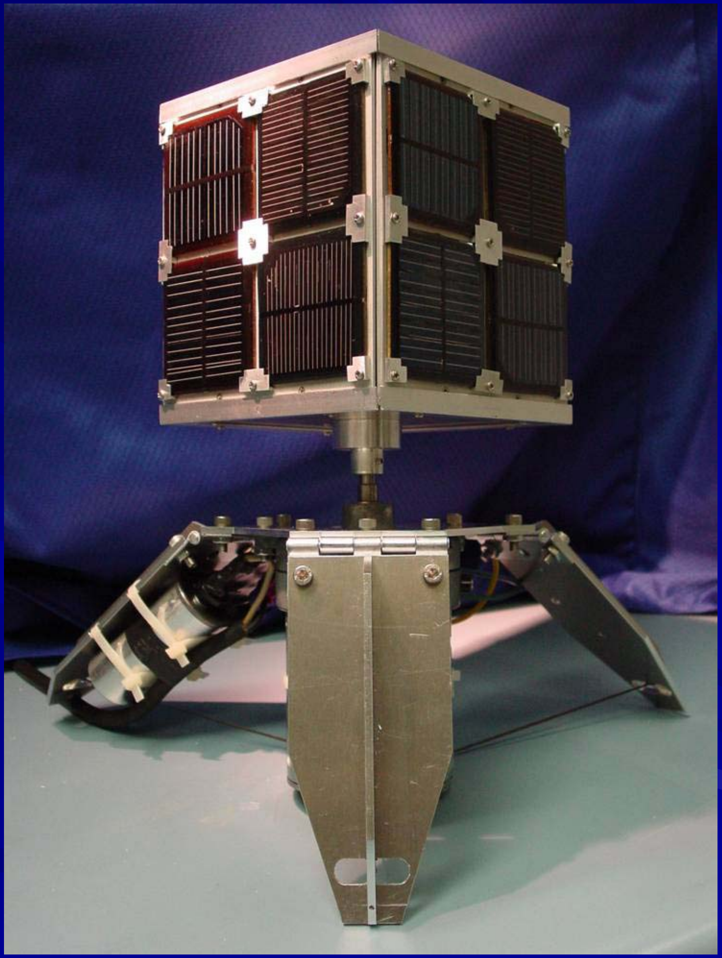


Signal generator

Solar cells on faces for power

Photos





Conclusion

- Modeling and testing performed on free-space communications systems
- BDRFs measured for numerous materials
- Developed and implemented IR communication systems based on:
  - Mil-STD-1553 bus
  - RS232 system
- Implemented IrDA IR communications system in test model

Acknowledgements

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